On Eight Meteoric Fireballs seen in the United States from July, 1876, to February, 1877.

By Daniel Kirkwood, Professor of Mathematics in Indiana University, Bloomington, Indiana.

(*Read before the American Philosophical Society, March* 16, 1877.)

The number of meteoric fireballs observed in the United States during the latter part of 1876 and the beginning of 1877 has been quite remarkable. In several instances the meteors have exploded with tremendous detonations, and the disruption has been followed by the fall of ærolites. The description and analysis of the latter will doubtless be given to the scientific world by those who have devoted special attention to this department of research. In the meantime some account of the *meteoric* phenomena will not be without interest.

I.

The Great Meteor of July 8, 1876.

On the evening of July 8th, 1876, about fifteen minutes before nine o'clock, Chicago time, a very large meteor passed over Ohio and Michigan, and was visible in the adjacent States of Iowa, Illinois and Indiana. At Wolcottville, La Grange County, Indiana, it was well observed by Mr. William L. Taylor, a member of the senior class in Indiana University, who states that the point of first appearance was almost exactly East of Wolcottville, and at an elevation of nearly 60°. At Valparaiso, Porter County, Indiana, according to Rev. Robert Beer, it appeared a little North of East ; while at Chicago it seemed to start from a point somewhat South of East and about 25° above the horizon. Mr. Benjamin Vail, of Henryville, Clarke County, Indiana, and Mr. J. W. Hollingsworth, of Paoli, Orange County, each saw the meteor under favorable circumstances. According to the former, its direction from Henryville, when first visible, was about North North-east. The observations of Messrs. Taylor and Vail thus determine the point of first visibility, while the notes of Mr. Hollingsworth, in connection with observations at Bloomington, Indiana, indicate almost precisely the same position. The body was first seen over Fulton County, Ohio, not far from latitude 41° 40′ North, longitude 84° West.

Altitude when First Visible.

Mr. Vail, who is known by the writer to be generally accurate, says the apparent altitude of the meteor when first seen at Henryville, was about 20°. The distance from that place to Ottokee, Fulton County, Ohio, is 226 miles. Mr. Vail's observation gives, therefore, about 88 miles as the vertical height of the meteor when first observed. The Paoli, Wolcottville, and Chicago observations indicate very nearly the same result.

The Point of Disappearance—Course and Length of the Visible Track.

The meteor crossed the meridian of Paoli at Berrien, Michigan ; the difference of latitude of the two positions being 235 miles. Mr. Hollingsworth says : "My observer, Mr. J. M. Andrew, describes the meteor as 'grazing' a chimney-top which was *on* his meridian 400 feet distant, and 51 feet more elevated than the observer's eye." The angle of elevation when on the meridian of Paoli was, therefore, 7° 16′. Taking into account the curvature of the earth's surface, these data give 37 miles as the altitude of the body when passing Berrien, Michigan. At Wolcottville, La Grange County, Indiana, the bearing of the point of disappearance was North 70° West, and its apparent elevation about 25°. At Chicago it was stated to be at an elevation of 50°, and somewhat North of East. These observations indicate a point over Lake Michigan, in latitude 42° North, longitude 86° 55′ West. This point is 40 miles from Chicago, 78 from Wolcottville, and 135 from Ottokee, Ohio. The altitude of the meteor at the time of its disappearance, according to the observations at Chicago and Wolcottville, was about 34 miles ; the bearing of the track, or of its projection on the earth's surface, was North 78° West ; and it was inclined to the horizon at an angle of 21°. The meteor passed vertically over the counties of Fulton and Williams, Ohio ; the North-east angle of Steuben County, Indiana ; and Branch, St. Joseph, Cass and Berrien, Michigan.

"The meteor was a very brilliant one. It lighted up the sky like the glare of a calcium light ; the intensity being several times greater than the light of the full moon."* Its mass was apparently dissolved or dissipated in the latter part of its track, leaving a luminous train which continued visible at least 40 minutes. The disappearance of the body was followed by no detonation, and if any meteoric fragments fell from the terminus of the track they must have been lost in the lake. No part of the mass, it is sufficiently obvious, could have passed out of the atmosphere.

The rare occurrence of meteors whose trains remain visible from fifteen minutes to an hour or more, seems to indicate a remarkable peculiarity in their structure and composition. Professor Ennis has suggested that they probably consist of elements easily combustible, such as potassium, sodium, calcium and magnesium.†

This meteor's motion about the sun was retrograde. The observations, however, furnished no data—or none sufficiently trustworthy—for determining either its orbital velocity or the nature of the orbit in which it moved.

II.

The Second Meteor of July 8, 1876.

Soon after the appearance of the meteor above described, the writer in a published note expressed his regret that the observations furnished by

*Chicago *Tribune.*

† Proc. of the A. A. A. S., Indianapolis Meeting.

correspondents were insufficient to determine, even approximately, the orbit of the meteor. In response to this note a communication was received from E. Lyon Linsley, of Stratford, Connecticut, who, on the same evening and nearly at the same hour, had observed a large fireball, and who supposed it to be identical with that seen in Michigan. The following is an extract from the Stratford letter:

"I saw this brilliant meteor here, on the evening of July 8th, at about nine o'clock. It was then about eight degrees from the polar star, and close to the faint northernmost visible star in the constellation *Camelopardalis*. Whether it expired then and there or disappeared behind an angle of the roof, I am unable to say; viewing it as I did from an Eastern portico, which was suddenly all aglow with its celestial light, and seeing meteor and illumination each but for a moment."

The slightest examination shows that the bolide here described was different from that seen in Michigan and the adjoining States on the same evening. We conclude accordingly that two fireballs of great brilliancy were simultaneously observed. Were they cometary fragments whose orbit intersects that of the earth near the 288th degree of longitude? It is a remarkable coincidence that on the 8th of July, 1856, somewhat earlier in the evening, a large fireball was seen in Alabama and Mississippi, which, like the meteor first described, left a luminous train that remained visible a considerable time near the terminus of its track.* It may also be mentioned as an additional coincidence that a meteoric stone-fall occurred in Spain on the 8th of July, 1811.

III.

The Fireball of December 16, 1876.

A large majority of the meteorites which reach the earth's surface must doubtless fall into the ocean, though the phenomena of their descent are very rarely witnessed. An occurrence of this kind was observed, however, according to the San Francisco daily papers, on Saturday morning, December 16, 1876, about fifteen minutes before one o'clock, when a large meteoric fireball appeared over the Pacific Ocean westward from San Francisco. When first seen it was rapidly descending towards the surface of the ocean, its apparent path making a large angle with the horizontal plane. It had been visible but a few seconds when it plunged into the Pacific at apparently no great distance from the shore. The fall was followed by a loud detonation.

IV.

The Meteor of December 21, 1876.

On Thursday evening, December 21, 1876, about seventeen minutes before nine o'clock, Bloomington time, a meteor of extraordinary magnitude passed over the States of Kansas, Missouri, Illinois, Indiana, Ohio,

* See Am. Journ. Sci. for November, 1856, and January and May, 1857.

Pennsylvania and New York. I have received communications descriptive of the phenomena from Prof. F. W. Bardwell, of Lawrence, and Rev. J. L. Gay, of Parsons, Kansas; Prof. Joseph Ficklin, Columbia, Mo.; Prof. S. W. Burnham, Chicago, Ill.; Profs. D. E. Hunter, Brookston, and J. B. Roberts, Indianapolis, Ind.; Prof. Samuel J. Kirkwood, Wooster, O.; and others in the different States over which the meteor passed. At Bloomington, Ind., it was observed by Profs. T. A. Wylie, D.D., H. B. Boisen, and C. F. McNutt; also by Rev. James Garrison, Messrs. D. O. Spencer, J. Graham, and many others. A discussion of the observations furnished by the correspondents named gives the following as

The Meteor's Track through the Atmosphere.

The body when first visible was about 70 or 75 miles above the earth's surface, at a point South-west from Emporia, Kansas, and not far from the Southern border of the State. It passed Emporia a few degrees South-east of the zenith; entered Missouri near the South-west corner of Jackson county; passed very nearly over the towns of Lexington, Keytesville, and Oakdale, Missouri; Quincy, Lewiston, Peoria, and Lorain, Illinois; Winamac, Rochester, and Auburn, Indiana; Bryan and Toledo, Ohio; crossed Lake Erie to a point a few miles South of Erie, Pennsylvania, and disappeared over South-western New York. This track is not represented by a straight line drawn on the map, but by one somewhat curved towards the North or North-west. Its length is between 1000 and 1100 miles—one of the longest meteoric tracks on record. The body passed the meridian of Bloomington, Indiana, 131 miles North of the city, and its apparent elevation as determined by Prof. T. A. Wylie, D.D., was 15°. This, taking into account the curvature of the meridian, gives about 38 miles as the altitude of the meteor when over the Western part of Fulton county, Indiana. Data furnished by Prof. Samuel J. Kirkwood, of Wooster, Ohio, show the height when over Lake Erie, directly North of that city, to have been 29 miles. The estimated altitudes at other points of the track are less satisfactory.

Explosions.

Some observers in Missouri report an explosion of the meteor when passing over the central part of the State. At Bloomington, Indiana, Prof. H. B. Boisen, who saw the meteor when due West and watched it till it disappeared near the Eastern horizon, observed it separate into several parts when nearly North-west, or in the direction of Peoria, Illinois. Rev. James Garrison, who resides one mile South of Bloomington, noticed by his clock the time of the meteor's disappearance and also that of the subsequent rumbling sound together with the violent jarring of his house. The interval was 15 minutes, indicating a distance of 185 miles. The sound and jar of the explosion were heard and felt by hundreds throughout Monroe county, and by many ascribed to an earthquake. In regard to the sounds following the meteor's passage through the atmosphere, the

Monthly Weather Review for December, 1876, says: "No reliable accounts speak of any noise heard during the visibility of the meteor, but in from two to five minutes after its passage a shock resembling thunder was heard, which in the majority of cases was described as tremendous, shaking the ground and the houses, and was especially alarming to those who, on account of the prevailing cloudiness, were unable to see the preceding meteor. The uniform character of the sound heard at all the stations shows that it was not due to any violent explosion (properly so-called), but was a peculiar acoustic phenomenon, depending on the fact that that portion of the line described by the meteor when nearest to any observer, became, as it were instantaneously along a length of several miles, the origin of a series of simultaneous sounds which, although in themselves comparatively feeble, were concentrated into a violent sound when they reached the observer's ear." The view here expressed is not sustained by the observations in Monroe and the adjacent counties, as a sound from the nearest point of the meteor's track would have reached Bloomington, if at all, in 10 or 11 minutes.

When crossing Indiana the principal fireball was followed by a train or group of smaller meteors, many of which were superior in apparent magnitude to Venus or Jupiter. The breadth or apparent diameter of this cluster, as seen from Bloomington, was three degrees, and its length at least twenty degrees. Its true diameter was therefore five miles, and its length about forty miles. These smaller meteors were chiefly the results of the explosions over Central Illinois A final disruption occurred over Erie county, Pennsylvania; several minor explosions having taken place during the passage over Indiana and Ohio.

The Fulton County Fragment.

A fragment of the meteorite fell on the farm of Mr. Andrew J. Morris, three miles North-west of Rochester, Fulton county, Indiana. Mr. M., on hearing the meteoric explosion, had left his house, when he noticed a heavy body strike the earth at no great distance. Designating the spot as nearly as he could by a mark in the snow (which was six inches deep), he returned in the morning, and soon found where the meteorite had struck in the snow, rebounded and again fallen close by. The whole fragment weighed about 12 ounces. A part of it was secured by the writer and forwarded to Prof. Chas. Upham Shepard, of Amherst College, Mass. A fragment was also obtained by Mr. W. A. Roebling, of New York, and a third was sent by Prof. E. T. Cox to Dr. J. Lawrence Smith, of Louisville. No analysis, however, has yet been published. The body is peculiar in its structure; being pisolitic and remarkably friable. The fact that other portions of the mass have not been discovered may perhaps be owing to its complete disintegration.

Did the Meteor Pass Out of the Atmosphere?

The observations at Bloomington, Indiana, and Wooster, Ohio, indicate that in a flight of 200 miles eastward from Rochester the altitude dimin-

ished from 38 to 29 miles. The elevation, when over Erie County, Pennsylvania, was almost certainly less than 30 miles—probably not more than 25. After the explosion, near the South-western border of New York, the meteor became almost immediately extinct. In view of these facts it seems extremely improbable that any part of the mass could have escaped out of the atmosphere. What became of the dissevered fragments, or why none have been hitherto found near the terminus of the track, may be difficult of explanation.

Velocity.

I have not learned that the time of the meteor's visibility was by any one accurately measured. The slowness of the apparent motion was, however, very remarkable; being compared by many to that of a flock of wild geese. Several observers estimated the duration of flight at nearly two minutes. The velocity with reference to the earth's surface was probably between 8 and 12 miles per second, and with reference to the sun, between 25 and 30.

V. and VI.

The Meteors of January 3 and January 20, 1877.

The fall of ærolites, attended with the usual meteoric phenomena, occurred in Warren County, Missouri, on the 3d of January, 1877, and in Georgia, January 20th. Fragments of these bodies have been secured by Professor J. Lawrence Smith, of Louisville, Kentucky, from whom full descriptions and analyses may soon be expected.

VII.

The Meteor of January 23, 1877.

About 4 o'clock on Tuesday afternoon, January 23, 1877, a splendid meteor was seen at Gray's Mills, five miles North of Bloomington, Monroe County, Indiana, by Mr. Daniel J. Stout and several other gentlemen in company with him. Its position when first seen was nearly South-east from the place of observation, and about 35° above the horizon. Its visible track was very nearly perpendicular to the earth's surface. When near the horizon the meteor disappeared behind a hill South-east of the observers, but the disappearance was followed by no detonation. The same meteor was observed by a number of persons in Decatur County, five miles East of Greensburgh, latitude 39° 27′ North, longitude 85° 28′ West. According to the Indianapolis *Daily Journal*, of January 25th, the meteor "disappeared just as it seemed to touch the earth, apparently not more than one-fourth of a mile distant. It presented the appearance of a flexible band of beautifully polished silver, and as it pursued its downward course waved like a ribbon in the breeze. Exclamations of astonishment and admiration burst simultaneously from the lips of all who saw it." A letter in the Cincinnati *Weekly Gazette*, dated at Scott's Post Office, Kenton County,

Kentucky, January 25, states that "about 4 o'clock on the evening of the 23d, a heavy rumbling sound was heard, as if coming from a South-easterly direction, and from a point high in the heavens. The report was likened by some to the discharging of numbers of heavy ordnance, the different discharges barely distinguishable. The concussion was sufficient to rattle the glass in the windows, and also to jar the earth quite perceptibly. The course of the sound appeared to be from a point South South-east" of the writer's place of observation. The final explosion took place over Harrison County, Kentucky, and the ærolite reached the earth nine miles North of Cynthiana. It is now in the collection of Dr. J. Lawrence Smith, of Louisville.

The points from which this meteor was observed in Decatur and Monroe Counties are nearly on the same parallel; the latitude of the former being about 39° 27′, that of the latter 39° 21′. The distance between the stations is 56 miles, and the entire track, as seen from Decatur County, was East of the meridian. The observations in Monroe County indicate that the height of the meteor when first seen was at least 70 miles.

VIII.

The Meteor of February 8, 1877.

About half past 2 o'clock on Thursday morning, February 8th, 1877, a large meteor was seen by J. S. Hunter, Esq., near Ellettsville, Monroe County, Indiana. The apparent magnitude of the body seemed equal to half that of the full moon, and the sudden light was so intense as to frighten the horse of the observer. The meteor was first seen in the South-east, crossed the meridian South of the zenith, and disappeared at a point about 30° or 35° South of West, and 10° above the horizon. Numerous sparks were emitted by the body in the latter part of its track, and a luminous train remained visible several seconds. No explosion was heard.

Bloomington, Ind., *March* 7, 1877.

On the Asserted Antagonism between Nicotin and Strychnia.

By Francis L. Haynes, M. D., Assistant Surgeon to the Episcopal Hospital.

(*Read before the American Philosophical Society, March* 16, 1877.)

History.

Haughton's Experiments. The Rev. Prof. Haughton, in a communication read before the Royal Irish Academy, in Nov. 1856, was the first to call attention to the subject under consideration. He related the details of the following experiments on frogs: 1. A frog was placed in a bath composed of five ounces of water and five grains of nicotin. It died in twenty-three minutes. 2. A frog was placed in a bath of twenty ounces of water